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Patterns of regional inflation persistence in a C.E.E. country. The case of Poland

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ABSTRACT

This paper investigates patterns of regional inflation persistence in Poland, a representative Central and Eastern European (C.E.E.) country. This study first argues that the C.E.E. perspective is relevant in the context of this study, due to the recent transitions, incomplete processes of forming forward-looking inflation expectations and pronounced spatial inequalities. Using individual and panel regressions on disaggregate data, this study provides evidence of the aggregation bias and marked differences in inflation persistence across product categories. Furthermore, it shows that cross-regional differences in inflation persistence remain, even after controlling for the product category. While this study generally confirms the earlier finding of Vaona and Ascari that more backward regions exhibit higher consumer price index inflation persistence, we also show that the picture is more nuanced at the product category level.

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1. Introduction

Inflation persistence is often defined as the extent to which shocks in the past have an effect on current inflation (Fuhrer & Moore, 1995). Understanding how shocks that have affected inflation in the distant past are reflected in current inflation, as well as how long it takes for inflation to approach a new equilibrium after a shock, is crucial for a central bank in determining its response in order to reach the desired objectives (Ascari & Sbordone, 2014). It thus, comes as no surprise that inflation persistence has attracted considerable research interest around the world, manifested in the works of Steinsson (2003), Benigno and Lopez-Salido (2006) or Stock and Watson (2007), to name just a few of many.

Theoretical underpinnings, which can serve to improve understanding of the nature of inflation persistence, are very rich. In an excellent survey, Cecchetti and Debelle (2006) show that canonical versions of time-dependent and state-dependent price-setting models predict no inflation persistence, while the limited information models typically introduce only a small amount of it. They make an obvious, yet important distinction between price level persistence and inflation persistence. In time-dependent models, such as those proposed by Taylor (1980) or Calvo (1983), prices are determined in a sequence of overlapping

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contracts, which are set based on contemporary available information and last for a fixed *n* number of periods. This implies that all shocks to price levels will have an impact on these prices for the subsequent *n*-1 periods. However, these price-setting mechanisms do not generate any persistence in the rate of inflation, especially that the price-setters are forward-looking. On the contrary, inflation immediately moves to the new level, following the shock. Also, state-dependent models, such as the menu-cost based price-setting mechanism, do not provide any direct and universal link between individual price changes and inflation persistence. What is more, even the impact on aggregate price level persistence is not unambiguously determined as it can differently respond to individual price changes, depending on the length of contracts, price elasticities of demand and also the properties of shocks themselves. Only in the limited information models, price adjustments are slowed down by the time of solving the information problem of price-setters, which leaves some room for gradual changes of inflation after the shock, i.e., the persistence.

Cecchetti and Debelle (2006) argue that the most important source of inflation persistence lies in inflation expectations. The more they are backward-looking, the more persistent inflation is in the economy. Should agents be purely forward-looking, inflation persistence would be zero. As inflation expectations can be influenced by the monetary policy, some studies investigate (and find positive) the role of following the inflation targeting strategy and of overall monetary policy credibility for bringing inflation persistence down (Sargent, 1999; Erceg & Levin, 2006; Orphanides & Williams, 2005).

The rising interest in inflation persistence has been accompanied by growing interest in the behaviour of prices and inflation rates at disaggregate levels (Clark, 2006). Both Erceg and Levin (2006) and Barsky, House, and Kimball (2003) were mostly interested in durable and non-durable goods and both found that prices of the former are more sensitive to monetary policy shocks. Babecky, Coricelli, and Horvath (2009) investigated detailed product-level consumer price indices in the Czech Republic and find that raw goods and non-durables, followed by services, display smaller inflation persistence than durables and processed goods. They also explicitly provide evidence for the aggregation bias in the form of high aggregate inflation persistence, relative to persistence in the underlying disaggregated series. Also, Clark (2006) finds that average persistence of disaggregate inflation is consistently below aggregate persistence and, thus, adds support to the problem of aggregation bias. Contrary to the results of Erceg and Levin (2006), Barsky et al. (2003), Babecky et al. (2009) and Clark (2006) finds no difference in inflation persistence between these product categories (and also services), even though considerable differences are found at a higher level of disaggregation. Interestingly, the results of Altissimo, Mojon, and Zafaroni (2007) are exactly the opposite: they find inflation to be most persistent in the case of food, housing and transportation. The second group (with some signs of positive persistence) encompasses alcohol and tobacco as well as furniture and health, with positive but very low persistence. Finally, communication, miscellaneous, recreation, clothing, restaurants and education all fall into the third group, with small and negative inflation persistence. Altissimo et al. (2007) arrive at some other interesting results. Most importantly, they show how high volatility and low persistence, observed on average at the level of sectoral inflation, are consistent with the aggregate smoothness and high persistence. Additionally, they document the strong cross-sectoral heterogeneity of the propagation mechanism of shocks.

Within-country regional inflation processes have so far received less attention, with some notable exceptions. For example, Cecchetti, Mark, and Sonora (2002) find a very

slow rate of convergence between price levels across U.S. cities, which they attribute to transportation costs, differential speeds of adjustment to small and large shocks and the role of non-tradable goods.

The closest to our study (and its inspiration) is the paper by Vaona and Ascari (2012), who investigate a provincial, disaggregated inflation series in Italy. They show that, economically, inflation persistence is indeed statistically different across Italian provinces and that backward regions display greater inflation persistence. This paper might be considered a convenient benchmark for our study, also because of some similarities between Italy and Poland. They are two similar-sized European countries with strong cross-regional divide. The North–South divide in Italy broadly corresponds to the West–East divide in Poland.

To summarise, the aim of this paper is to shed some light on disaggregate inflation persistence in Poland. More specifically, it identifies product groups and regions that exhibit highest and lowest inflation persistence, and tests whether cross-regional differences remain after sectoral differences are accounted for. Finally, some inference is drawn to address the hypothesis of Vaona and Ascari (2012) that inflation persistence is related to economic backwardness of a region.

2. The C.E.E. perspective

As noted in the previous section, the primary sources of inflation persistence are considered to be inflation expectations. The Central and Eastern European (C.E.E.) experience with centrally-planned economies, usually rapid transitions and subsequent rapid economic integration with the E.U., must have affected the process of forming inflation expectations in these countries. This is where the first C.E.E.-specific element kicks in. The process of forming forward-looking inflation expectations takes time and is largely dependent upon monetary policy credibility. To build the latter, it also takes time.

The environment for conducting monetary policy in C.E.E. (and building its credibility) has been very challenging due to the multitude of constraints and forces shaping national inflation developments. Indeed, countries there are typically relatively vulnerable to international capital flows and monetary policy actions taken in the Eurozone, while also coping with internal shocks related to their more dynamic economic structures, progressing privatisation, etc. Additionally, the monetary policy environment has been constantly changing in the past three decades, which forced frequent adjustments in monetary and exchange rate policy regimes. Poland again serves as a good example of a C.E.E. country, which in the past decades had no choice but to adapt to the rapidly changing conditions. Starting from 1990, the monetary policy target there evolved from combating post-transition shock hyperinflation with the help of money supply control, while also preserving the exchange rate fixed (with a changing currency basket), through following a crawling peg and enforcing disinflation, all the way towards introducing inflation targeting (from 1998 on) and a flexible exchange rate (from 2000 on) in the dynamic environment of progressing integration with the E.U., which was gradually limiting the scope of independent monetary policy vis-à-vis the Eurozone. It should be acknowledged that, despite these turbulent conditions, most C.E.E. monetary policies have been fairly successful in stabilising their economies, achieving price stability and building credibility. Admittedly, the progress in the latter element has not been equal and largely depends on initial conditions and starting dates of the economic transitions. Most studies would find Czech monetary policy as

the most successful in establishing it credibility as well as raising forward-lookingness of inflation expectations, followed by Slovakia (now a Eurozone member), followed by Poland and Hungary (Arestis & Mouratidis, 2005; Baxa, Plasil, & Vasicek, 2015). However, a recent study of Sousa and Yetman (2016) provides evidence that, in four C.E.E. countries (Czech Republic, Hungary, Poland and Romania), inflation expectations have already been fairly firmly anchored, which speaks in favour of monetary policy credibility. Also, Baranowski and Gajewski (2016) show that the National Bank of Poland put its monetary policy to a credibility test in 2013 and 2014 by launching forward guidance, and this test can be considered as passed. All this most recent evidence would suggest that C.E.E .monetary policies are advanced in the process of credibility-building, although the finding of Franta, Saxa, and Smidkova (2010), who show that backward-looking behaviour may be more important in explaining inflation dynamics in C.E.E. countries than in "old" E.U. member states, will probably remain valid for some time.

As outlined in the previous section, existing empirical evidence also points to substantial differences in inflation persistence across product categories and regions. The extent to which this aspect is valid in C.E.E. countries thus depends on intra-national disparities. Monastiriotis (2011) examines the growth process in C.E.E. countries since the start of their transition to market economies, through the prism of spatial patterns. He shows that the catching-up processes vis-à-vis Western Europe observed at the national level were accompanied by a 'complex pattern of non-linear regional growth dynamics with convergence tendencies largely swaddled by processes of cumulative causation' (Monastiriotis, 2011). Consequently, regional evolutions were generally found divergent, hereby deepening existing disparities and polarisation. Similar conclusions, of relatively large and growing regional disparities in C.E.E. countries, compared to the rest of the E.U., are reached by Smętkowski (2013). It should be acknowledged that this aspect is also relevant in relatively small countries of the region. Banerjee and Jesenko (2015) and Dokic, Frohlich, and Bakaric (2016) demonstrate substantial regional development disparities in Slovenia and Croatia, respectively.

To summarise this section, there is a strong rationale behind investigating inflation persistence with a special focus on disaggregate approaches, in C.E.E. countries. Both the incomplete process of forming forward-looking inflation expectations and sizeable (and growing) regional disparities make inflation persistence an even more important problem there than in many developed countries with a long-track of credible inflation-targeting and more balanced regional distribution of growth and development.

3. Data and empirical model

To the best of our knowledge, the Polish Central Statistical Office (Główny Urząd Statystyczny, G.U.S.) is the only one in C.E.E., which provides the NUTS-2 level consumer inflation series, also disaggregated to main product categories, at both annual and quarterly frequency. It is obvious that quarterly data is more appropriate for investigating regional inflation persistence. In C.E.E. there are at least two reasons for that. First, annual frequency is generally too low to capture persistence. For example, Vaona and Ascari (2012) impose 1 year (four quarters) as a maximum length of persistence and find that in most regions coefficients are statistically significant only up to one or two quarters. Second, annual frequency would require collecting data from at least 30–40 years, in order to make individual estimations

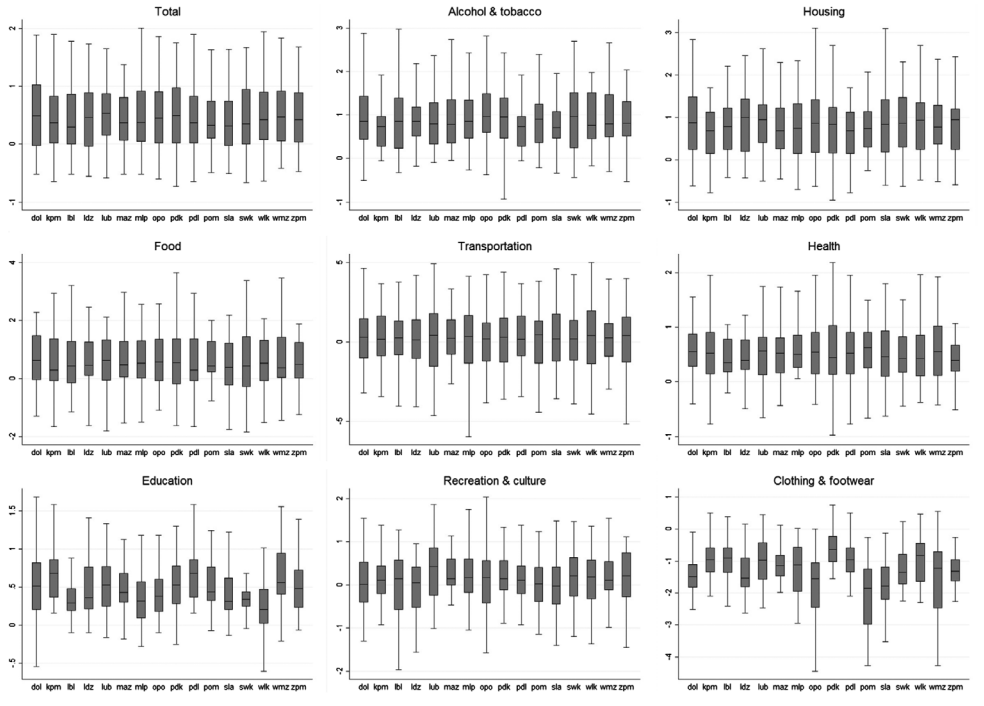

Figure 1. Descriptive statistics of series used in empirical analyses. Source: Own calculations.
Notes: Source of data: Polish Central Statistical Office (Główny Urząd Statystyczny, G.U.S.).

feasible. However, C.E.E. countries have undergone transitions in the last 30 years (in some cases they are still being completed). Prior to these transitions, consumer prices heavily relied on administrative decisions. This makes prices in pre-transition periods not comparable with post-transition prices, and incorporating them would introduce severe bias to our results.

We use a data-set containing quarter-on-quarter consumer price index (C.P.I.) changes, spanning from the 1st quarter of 2005 to the 3rd quarter of 2016 for 16 Polish voivodships (NUTS-2 regions), also disaggregated into eight product categories (education, food & non-alcoholic beverages, alcohol & tobacco products, clothing & footwear, housing, health, transport, recreation & culture). The source of data is the Polish Central Statistical Office (Główny Urząd Statystyczny, G.U.S.), and we seasonally adjust all series using the X-13-ARIMA-SEATS method. Descriptive statistics of all our 144 series are presented graphically as boxplots in Figure 1. There we can observe that the disinflation process in Poland, which started in the early 1990s from the hyperinflation accompanying rapid transition, had been firmly completed before the starting point of our sample. Not only the aggregate C.P.I. inflation, but also price indices in all other product categories, do not reveal any track of unusually high values and deviations from the mean are broadly symmetric.

Altogether, during the sample period the country enjoyed a stable economic environment without strong trends and major shocks. The post-E.U. entry shock faded before the starting point and the 2008 global crisis had only a muted impact on the Polish economy. This is why the conventional augmented Dickey-Fuller (A.D.F.) unit root test, which we execute

Table 1. A.D.F. unit root test results.

	alct	educ	hous	clot	recr	totl	tran	heal	food
Dolnośląskie (dol)									
Z(*t*)	−3.85	−4.18	−3.23	−4.28	−6.18	−2.93	−4.43	−5.23	−4.28
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kujawsko-Pomorskie (kpm)									
Z(*t*)	−3.60	−5.02	−3.27	−5.25	−6.25	−3.06	−4.67	−4.43	−3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubelskie (lbl)									
Z(*t*)	−3.28	−5.66	−2.28	−6.54	−4.65	−2.58	−4.56	−5.41	−3.51
p-val	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Łódzkie (ldz)									
Z(*t*)	−3.89	−4.83	−2.27	−4.05	−6.94	−2.82	−4.47	−5.27	−4.23
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Lubuskie (lub)									
Z(*t*)	−3.32	−4.06	−3.00	−4.33	−6.97	−3.71	−4.63	−5.17	−5.22
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mazowieckie (maz)									
Z(*t*)	−3.01	−4.69	−2.22	−5.01	−6.20	−2.57	−4.40	−4.71	−4.01
p-val	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00
Małopolskie (mlp)									
Z(*t*)	−3.75	−4.61	−3.14	−3.22	−6.93	−3.16	−4.91	−7.19	−4.48
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Opolskie (opo)									
Z(*t*)	−4.03	−4.11	−2.96	−3.79	−6.40	−2.94	−4.48	−4.86	−4.76
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Podkarpackie (pdk)									
Z(*t*)	−3.19	−4.56	−2.76	−4.07	−5.15	−2.86	−4.39	−5.55	−4.35
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Podlaskie (pdl)									
Z(*t*)	−3.60	−5.02	−3.27	−5.25	−6.25	−3.06	−4.67	−4.43	−3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pomorskie (pom)									
Z(*t*)	−4.46	−4.48	−3.35	−3.73	−5.75	−3.03	−4.63	−6.52	−3.81
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Śląskie (sla)									
Z(*t*)	−2.56	−4.74	−3.08	−4.88	−6.35	−3.36	−4.91	−4.79	−4.91
p-val	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Świętokrzyskie (swk)									
Z(*t*)	−3.80	−4.46	−2.48	−5.03	−6.01	−2.69	−4.81	−4.55	−4.32
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Wielkopolskie (wlk)									
Z(*t*)	−5.00	−6.21	−2.53	−3.23	−5.32	−3.05	−4.65	−5.74	−3.85
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Warmińsko-mazurskie (wmz)									
Z(*t*)	−3.13	−4.70	−2.72	−4.19	−7.11	−2.89	−4.58	−4.73	−4.00
p-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zachodniopomorskie (zpm)									
Z(*t*)	−3.11	−4.87	−2.65	−4.50	−6.52	−2.71	−4.32	−5.89	−4.82
p-val	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

Notes: alct- alcohol & tobacco; educ- education; hous- housing; clot- clothing & footwear; recr- recreation; totl- aggregate C.P.I.; tran- transportation; heal- health.
Source: Own calculations.

prior to our empirical exercise, does not raise any major concerns (Table 1). It rejects the null of non-stationarity at the 1% or 5% significance levels in all series.

There are several approaches to investigating inflation persistence. Most studies follow a statistical approach and assume univariate representation of the inflation process, which allows for calculating the sum of autoregressive coefficients, the largest autoregressive root or half-life as a measure of persistence (Carlos, 2004). A structural approach on the other hand relies on the Phillips curve with nominal rigidities modelled with a price adjustment mechanism. In the standard Calvo mechanism, for example, a fraction of firms is allowed to adjust prices in every period (Calvo, 1983). Even on the aggregate level, the statistical approach outperforms the structural one in terms of data fit (Franta et al., 2010). Earlier, Bils and Klenow (2004)showed that the Calvo model dramatically fails to fit the disaggregate data.

Our empirical exercise is, thus, performed in two steps. The first step relies on estimating a set of autoregressive models, as in Vaona and Ascari (2012):

$$\pi_{ijt} = \alpha_{ij} + \sum_{k_{ij}=1}^{K_{ij}} \rho_{ijk_{ij}} \pi_{ijt-k_{ij}} + u_{ijt} \tag{1}$$

where π_{ijt} is the quarter-on-quarter C.P.I. inflation rate in voivodship i, product group j, time t; α_{ij} is the region- and product group-specific intercept; K_{ij} is the lag length, determined individually in each of the 144 estimated equations with the help of the Bayesian information criterion (B.I.C.); and u_{ijt} is the error term. As we favour parsimony, each of the models is first estimated as AR(1) and AR(2) processes and the selection between them is based on the B.I.C. criterion. If AR(2) is preferred over AR(1), then we extend the number of lags and repeat the model selection procedure based on B.I.C. We also follow Vaona and Ascari (2012) in setting an upper limit of four lags to preserve degrees of freedom in individual estimations.

Even though the period under investigation was relatively stable (i.e., major shocks, related to the transition, or E.U. accession have already largely faded before 2005), some structural breaks may remain in our series, especially due to regulatory changes. Hereby, following Levin and Piger (2004), we perform the Wald test of the null hypothesis that the persistence parameter ρ does not exhibit a structural break with an unknown break date. Each model is also tested for misspecification, using the conventional Ramsey RESET test.

Having unveiled the strength of inflation persistence, a natural consecutive step would be to estimate cross-sectional models with autoregressive terms as a left-hand variable and a set of explanatory variables related to the economic structure, business sector demography, or geographic location to track some region-specific sources of inflation persistence. While this approach is used by Vaona and Ascari (2012), it is inaccessible in our case due to an insufficient number of cross-sections. However, we utilise some well-established facts on regional development patterns in Poland to track the role of backwardness for inflation persistence. As is well known, in terms of the level of development and some deep characteristics, related among others to economic structures and business sector structure, the country can be broadly divided into two parts: the more developed West (commonly referred to as Poland 'A') and a backward East (Poland 'B', see Gajewski & Tchorek, 2017). Admittedly, some voivodships, mostly those geographically located in the central part of the country, escape this division and do not unambiguously belong to either East or West. For the purpose of this study, we employ the East–West division, which emerges from the

formal extraction procedure performed by Gajewski and Tchorek (2017), who arrive at the following composition of the two groups of voivodships:

East: Lubelskie, Podkarpackie, Podlaskie, Warmińsko-Mazurskie and Świętokrzyskie.

West: Dolnośląskie, Lubuskie, Opolskie, Pomorskie, Wielkopolskie, Zachodniopomorskie and Śląskie.

The four voivodships which could not be unambiguously qualified to East or West are: Mazowieckie, Łódzkie, Kujawsko-Pomorskie and Małopolskie. The latter three voivodships form a central belt separating the West from the East. Mazowieckie, in turn, is structurally distinct because of comprising both large, underdeveloped agricultural lands on the one hand and the administrative and financial capital city of Warsaw on the other.

In the second step of our empirical analysis we pool all regional data and estimate panel-data models, in which we control for differences between the East and West macroregions with the help of interactive terms. The theoretical framework used here is the dynamic Phillips curve in a form proposed by Gordon (1970) or King and Watson (1994):

$$\pi_t = \beta + \sum_{k=1}^{4} \rho_k \pi_{t-k} + \sum_{l=0}^{L} \gamma_l u_{t-l} + \upsilon_t \tag{2}$$

where π_t and u_t are inflation and unemployment rates, respectively.

We augment the above relationship, so that our models have the following form:

$$\pi_{ijt} = \beta_{ij} + \sum_{k=1}^{K} \rho_{ijk} \pi_{ijt-k} + M_n \sum_{k=1}^{K} \rho_{ijk} + \sum_{l=0}^{L} \gamma_{ijl} u_{ijt-l} + \upsilon_{ijt} \tag{3}$$

where M_n is one of the two ($n = 2$) dummy variables that captures East and West macroregions, while subscripts i and j denote product category and region, respectively. Interactive terms $M_n \sum_{k=1}^{4} \rho_{ijk}$ capture deviations in the autoregressive coefficients between East and West from the reference group of regions. More precisely, a model is first estimated with interactive terms containing East and then the reference group is composed of all voivodships excluding those belonging to East. Then the same model is estimated with interactive terms containing West and the reference group becomes all regions excluding West.

4. Results

The first part of our empirical exercise leaves us with an estimated 144 individual autoregressive models. It should be acknowledged that the decision to constrain the number of lags to four was sensible, as in only five models were four lags selected. In fact, in most cases (68 models) one lag was the optimal choice. Two lags were chosen in 13 models and three lags in six models. In 52 models the first autoregressive coefficient was not significant, which was interpreted as evidence of no persistence in inflation.

The structural break and misspecification test results revealed some problems in series of four categories. Altogether, 20 out of 144 models turned out to be misspecified and we also found structural breaks in 33 models. A significant part of models that contain both problems overlap, as 123 models are free from any of them. Both misspecification and structural breaks were simultaneously found, mostly in education (13 cases of misspecification and six cases of structural break) and partly also in clothing and footwear (four and

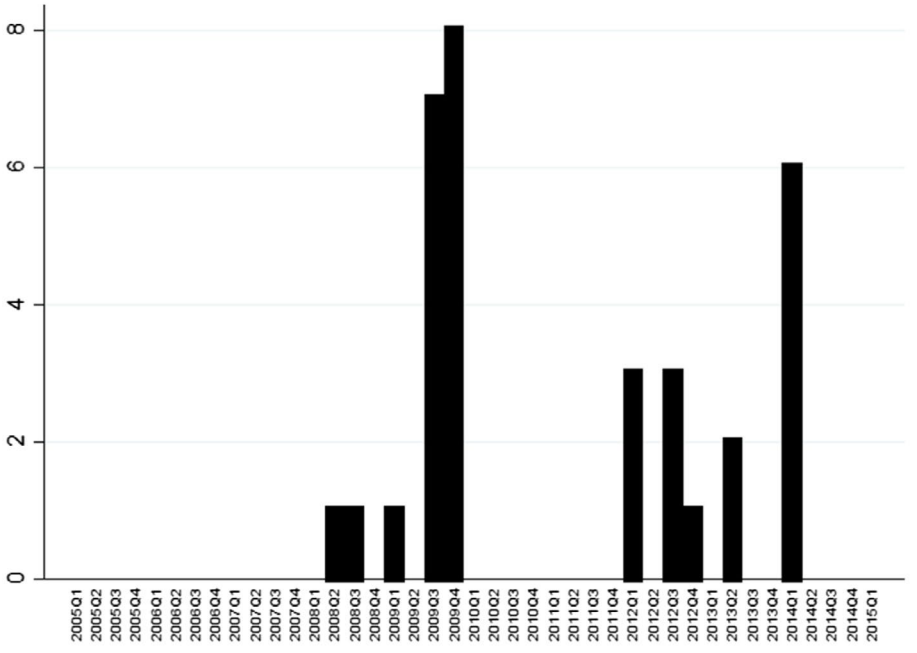

Figure 2. Histogram of structural breaks detected in regional inflation series. Source: Own calculations.

11 cases, respectively). Structural breaks were additionally revealed in health and alcohol and tobacco (seven cases in each category) and housing (two cases). Two models within the alcohol and tobacco category and one in the health category were also misspecified. We account for these results in further analyses: autoregressive coefficients obtained from misspecified models are not presented, while those collected from models that contain structural breaks are clearly marked. Figure 2 presents a histogram of the detected structural breaks. We observe their highest accumulation in the third and fourth quarters of 2009, followed by the first quarter of 2014. The first break date can be attributed to two categories: alcohol & tobacco and clothing & footwear, and it is associated with an increase of excise tax and market shifts, respectively, related to the abolishment of duties on clothing items imported from China. The 2014 break date, in turn, was detected in the education series, following an introduction of public subsidies to public kindergarten fees, which contributed to a decline of education prices by ca 10%.

Presenting detailed results for all 144 models is not feasible, given the space limitations, but Figure 3 illustrates the most important findings from these estimations. It presents autoregressive terms $\sum_{k=1}^{4} \rho_{t-k}$ for all statistically significant coefficients $\rho_{t\text{-}k}$ [1], up to the selected lag length.

Overall C.P.I. quarterly inflation persistence across Polish voivodships ranges from 0.52 to 0.73. In order to get a first glance at the relationship between persistence and backwardness, we take two series, for which we have no insignificant autoregressive terms, and compute correlation coefficients between inflation persistence on the one hand and per capita GDP as well as share of employment in agricultural sector on the other. The latter variable serves as a good C.E.E.-specific proxy of development lag. Indeed, this part of Europe still undergoes structural changes which are uneven in space. Regions which are dominated by agriculture tend to lag behind in many other respects as well.

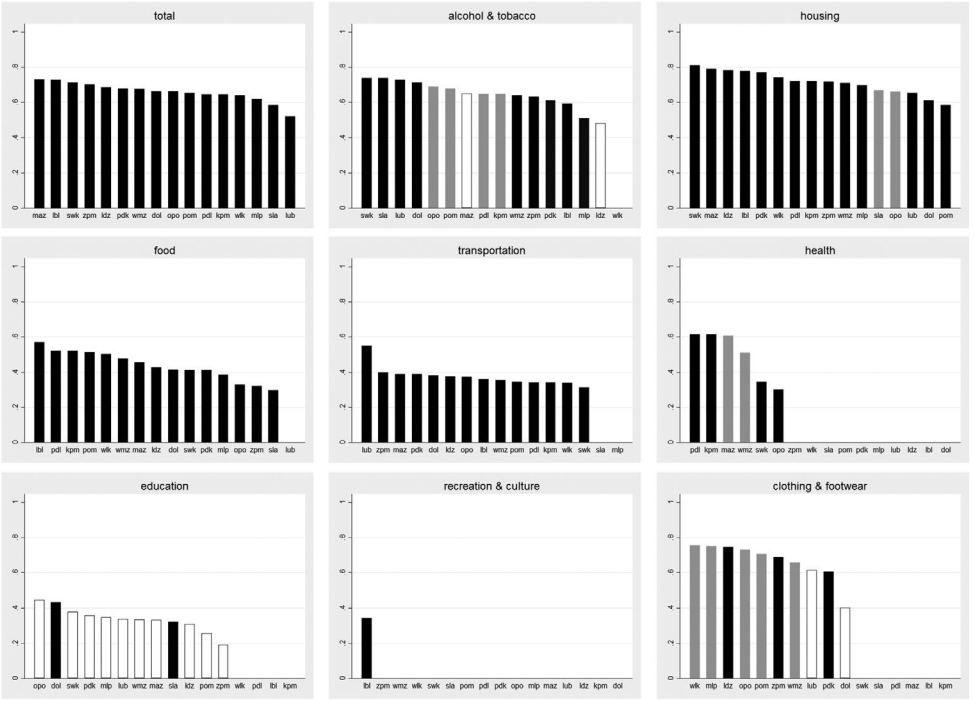

Figure 3. Estimated individual regional inflation persistence terms across product categories. Source: Own calculations.
Notes: No bar means no statistically significant autoregressive term; grey bar indicates structural break detected; white bar indicates misspecification problem.

As we see in Figure 4, there is a moderately strong and positive correlation between inflation persistence and importance of agriculture. An even stronger correlation is observed when aggregate C.P.I. inflation is replaced by housing price inflation. However, Figure 4 also suggests that the correlation between inflation persistence and per capita G.D.P is negligible. We believe that this result is due to another C.E.E.-specific feature, namely the concentration of development processes in capital cities (or a low number of largest metropolitan areas). At least during the first decades after the transition, growth tended to be concentrated in Warsaw, Prague, Budapest, Bucharest and other capital areas. In Poland, the otherwise agricultural Mazowieckie voivodship is home to the capital city of Warsaw, with its dynamic financial industry and headquarters of many international companies operating in Poland. When this outlier region is excluded, we arrive at a significantly negative, moderately strong correlation. In other words, taking into account the specific C.E.E.-related features, we are able to confirm the hypothesis of Vaona and Ascari (2012) that backward regions exhibit a higher degree of persistence, at least with regard to the aggregate and housing inflation rates in Poland.

As expected, and earlier documented, e.g., by Altissimo et al. (2007), we also find strong cross-product heterogeneity in inflation persistence. Housing and alcohol & tobacco products are marked by persistent inflation, while in the cases of food & non-alcoholic beverages and also transportation it turns out to be moderately persistent. On the other hand, we find no significant regional autoregressive components in the case of the recreation & culture category and only one significant autoregressive term in education, in the western Dolnośląskie

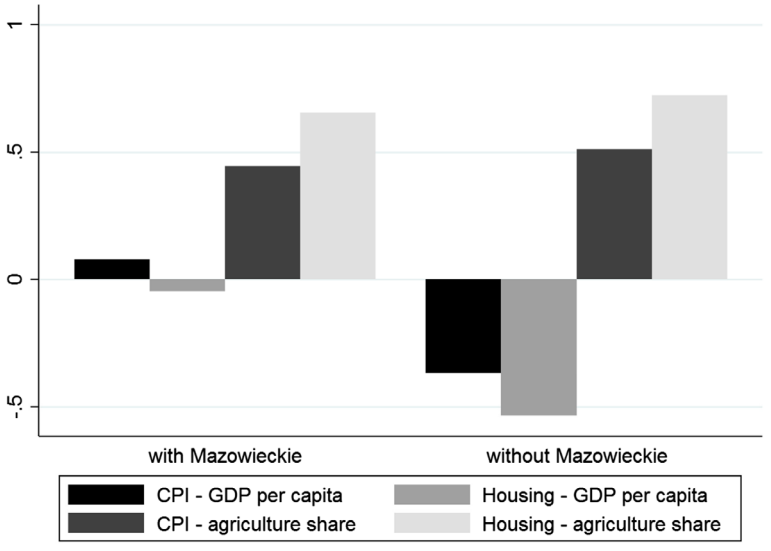

Figure 4. Correlation coefficients between inflation persistence and average per capita GDP and share of employment in agriculture*. Source: Own calculations.
*Average GDP per capita (Poland = 100) in the period 2005–2014, average share of employment in agriculture in the period 2005–2015.

voivodship. The remaining two product groups, clothing & footwear and health, reveal a dual nature: in some regions autoregressive terms are significant (and sometimes high, especially in clothing & footwear), while they appear insignificant in others.

Our results also support the aggregation bias hypothesis. The aggregate C.P.I. index seems to inherit persistence from its most persistent components, such as housing and alcohol & tobacco, and is well above the persistence in the remaining series.

In the second stage, we want to shed some light on the role of backwardness for inflation persistence by examining its patterns in the two distinct macroregions introduced in the previous section. The data is now pooled and panel models are estimated with interactive terms to capture differences in the slope (autoregressive) coefficients between both macroregions and the rest of Poland. Here, no restrictions are imposed on the lag structure, as we are mostly interested in the significance of deviations rather than the significance of coefficients on autoregressive terms in the reference groups of regions. Given our panel structure, i.e., relatively large (T = 48) and T > N, the Nickell (1981) bias is negligible and we can estimate the dynamic panel models with least square dummy variable (L.S.D.V.) Table 2 presents the results.

First of all, we observe that our panel regressions confirm earlier findings that aggregate C.P.I. index, housing and alcohol & tobacco inflation all display the highest persistence. Similarly, we find support of the result of no inflation persistence in the recreation & culture category, which is reflected in the insignificance of the first two autoregressive coefficients. Unlike in individual regressions, however, the persistence in the education category appears positive, although partly neutralised by negative second-lag autoregressive coefficients. Such a pattern can be responsible for the insignificant autoregressive terms, found in most our individual regressions.

Moving on to the east–west divide, we obtain some further noteworthy results. Most of all, we get additional support of the hypothesis that eastern voivodships (East) display

Table 2. Estimation results of panel models (3).

	C.P.I.		Food		Education		Housing		Alcohol & tobacco		Clothing		Recreation		Transportation		Health	
Region	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
π_{t-1}	0.49***	0.56***	0.33***	0.43***	0.37***	0.33***	0.57***	0.56***	0.41***	0.46***	0.29***	0.18***	0.01	0.03	0.36***	0.35***	0.15***	0.18***
	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.04)	(0.06)	(0.02)	(0.04)	(0.05)	(0.03)	(0.05)	(0.02)	(0.02)	(0.03)	(0.04)
π_{t-2}	0.02	−0.01	0.11***	0.04	−0.13***	−0.10***	0.13***	0.21***	0.02	0.07***	0.26***	0.29***	0.01	0.04	−0.10***	−0.08***	0.10**	0.21***
	(0.01)	(0.03)	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.05)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)	(0.06)
π_{t-3}	0.25***	0.22***	0.03	0.02	0.04	−0.01	0.10***	0.06	0.31***	0.34***	0.10*	0.10*	−0.09***	−0.14***	0.32***	0.25***	0.18***	0.15***
	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.05)	(0.05)	(0.02)	(0.03)	(0.02)	(0.03)	(0.04)	(0.03)
π_{t-4}	0.04**	0.05*	0.00	0.02	0.00	0.06	−0.02	−0.05	−0.07	−0.21***	0.00	0.06	−0.24***	−0.21***	−0.12***	−0.10***	−0.04	−0.18***
	(0.02)	(0.03)	(0.01)	(0.01)	(0.04)	(0.05)	(0.03)	(0.05)	(0.09)	(0.02)	(0.04)	(0.04)	(0.03)	(0.04)	(0.01)	(0.03)	(0.04)	(0.05)
Region* π_{t-1}	0.09**	−0.09**	0.12*	−0.14***	−0.05	0.06	−0.03	0.01	0.06	−0.06	−0.15*	0.14*	0.08	0.00	0.00	0.02	0.06	−0.02
	(0.04)	(0.03)	(0.06)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.07)	(0.09)	(0.08)	(0.07)	(0.08)	(0.06)	(0.03)	(0.03)	(0.04)	(0.04)
Region * π_{t-2}	−0.06	0.04	−0.09	0.09***	0.05	−0.04	0.14*	−0.10	0.06	−0.07	0.04	−0.04	0.07	0.00	0.02	−0.04	0.13	−0.15**
	(0.05)	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)	(0.07)	(0.06)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.06)	(0.04)	(0.03)	(0.08)	(0.07)
Region * π_{t-3}	−0.04	0.04	0.00	0.03	−0.08*	0.04	−0.03	0.05	0.06	−0.03	−0.05	−0.03	−0.08	0.06	−0.09**	0.09***	−0.07	0.01
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)	(0.05)	(0.08)	(0.08)	(0.06)	(0.04)	(0.04)	(0.03)	(0.05)	(0.06)
Region * π_{t-4}	0.02	0.00	0.03	−0.01	0.07	−0.08	−0.09**	0.01	−0.16*	0.19	0.12**	−0.04	0.04	−0.05	0.02	−0.04	−0.14*	0.18***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.08)	(0.06)	(0.04)	(0.05)	(0.09)	(0.12)	(0.05)	(0.07)	(0.07)	(0.05)	(0.04)	(0.03)	(0.07)	(0.05)
Unempl rate$_t$	0.00	−0.01	0.04*	0.04*	0.04	0.04	−0.02*	−0.02*	0.00	0.00	0.00	0.00	0.06**	0.06**	0.06	0.06	−0.03	−0.03
	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.02)	(0.02)
Unempl rate$_{t-1}$	0.01	0.01	−0.01	−0.01	−0.03	−0.03	0	−0.01	−0.02	−0.02	0.00	0.00	0.05	0.05	0.14**	0.14**	−0.01	−0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.02)	(0.02)
Unempl rate$_{t-2}$	0.00	0.00	−0.01	−0.01	−0.04	−0.04	0.02	0.02	−0.01	−0.01	−0.02	−0.02	−0.06**	−0.06**	−0.16***	−0.16***	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)	(0.04)	(0.01)	(0.01)
Intercept	0.05	0.05	0.18*	0.17*	0.58***	0.57***	0.21***	0.21***	0.59***	0.59***	−0.22*	−0.22*	−0.17**	−0.16**	−0.25	−0.25	0.55***	0.56***
	(0.05)	(0.05)	(0.10)	(0.10)	(0.14)	(0.14)	(0.05)	(0.05)	(0.07)	(0.07)	(0.11)	(0.11)	(0.08)	(0.07)	(0.20)	(0.20)	(0.04)	(0.04)
n	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688	688
R^2 (within)	0.48	0.48	0.18	0.18	0.13	0.13	0.5	0.5	0.38	0.38	0.27	0.27	0.08	0.08	0.2	0.21	0.11	0.11
Log-likelihood	−404.09	−404.18	−920.38	−919.62	−1095.37	−1095.12	−581.39	−581.97	−679.76	−678.42	−739.56	−740.87	−915.81	−916.62	−1398	−1397.81	−676.96	−675.6

Notes: Clustered, robust to heteroscedasticity standard errors in parentheses. Regional fixed effects controlled. ***, ** and * denote statistical significance at 1, 5 and 10%, respectively.
Source: Own calculations.

stronger overall C.P.I. inflation persistence than non-eastern ones. On the contrary, persistence in western voivodships (West) seems to be lower than elsewhere, although we acknowledge that the difference is only significant on the first autoregressive term. Beyond this, we find no strong evidence that more remote C.P.I. inflation rates influence today's inflation in a different way across both macroregions.

Even stronger deviations in persistence are found in the food products category, but, again, only when first lags are compared. The second lag in the West turns out higher than in other regions, while the East does not differ from the rest of the country in this respect. However, we should acknowledge that the pattern discovered in both the aggregate C.P.I. index and the food price index does not unambiguously hold in other categories. Most notably, there does not seem to be any deviations in persistence, neither between East nor West from the reference groups in two categories: alcohol & tobacco and recreation & culture. In the first group, it is a natural consequence of heavy regulation of spirits and tobacco markets with a country-wide impact of administrative decisions on prices. Within recreation & culture category on the other hand, we have both items, which are sold at identical prices across the country (e.g., newspapers, books) and some tradable items (e.g., audio-visual equipment), which can be easily purchased from distant locations, via the internet for example. Therefore, the room for regional price discrimination is only limited.

Inflation of clothing & footwear is, in turn, more persistent in West compared to East and the difference is only visible in the first lag. Differences of inflation persistence in the remaining three product categories (housing, transportation, health) are more subtle and embedded in the distribution of autoregressive terms more than in their sum. Inflation persistence of health-related products and services, for example, does not deviate in either of the macroregions initially, but the second inflation lag adds to the overall persistence in West, while the fourth lag removes a part of it. On the contrary, East is in this respect virtually undistinguishable from its reference group.

As a robustness check, we estimated equation (3), replacing East and West with the share of agriculture in total employment. The estimated autoregressive coefficients are very similar and the main conclusions are also confirmed (see Appendix Table A1).

5. Conclusions

The aim of the paper was to shed some light on regional inflation persistence in a C.E.E. country, with all its specific features. Poland was chosen, due to data availability and because it shares many peculiarities with other C.E.E. countries. Overall, our results are broadly in line with findings presented in some earlier studies. First, they add support to the existence of the aggregation bias, as documented by Clark (2006) and Babecky et al. (2009), but contrary to Vaona and Ascari (2012). Indeed, the aggregate C.P.I. index in our data-set displays similar persistence to its most persistent components (housing, alcohol & tobacco), being substantially higher than in the remaining series. Second, on the aggregate level we confirm the hypothesis that backward regions exhibit a higher degree of inflation persistence. However, when the C.P.I. index is disaggregated into more detailed product categories and if additional individual lags are accounted for, the picture becomes more complex.

Food & non-alcoholic beverages—the single most important C.P.I. product category—exhibits a very similar pattern to the aggregate C.P.I. index in terms of persistence differentials between East and West, while being even stronger. Since the share of food in household expenses diminishes with rising incomes, we may put forward a hypothesis that

cross-regional inflation persistence disparities might be relatively high in lower-income countries, at earlier stages of development, when growth is concentrated in the strongest urban centres and regional divergence is a common phenomenon. Over time, however, when growth spills over to other regions, incomes grow and this growth gains broader geographical base. Cross-regional differences in inflation persistence should also diminish.

Our panel regression results reinforce the conclusion that inflation is more persistent in the backward regions in Eastern Poland and less persistent in the West. In some product categories, the pattern seems to be more nuanced, however. More specifically, we find that rather than in the strength of the persistence, the difference between East and West lies in the shape of the impulse response of current inflation to past shocks. Such a situation is found in housing, transportation and health product categories.

Note

1. In models which were not found to be mis-specified.

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Appendix

Table A1. Alternative estimation results of panel models (3)—East/West replaced by the share of labour in agriculture.

	C.P.I.	Food	Education	Housing	Alcohol & tobacco	Clothing	Recreation	Transportation	Health
π_{t-1}	0.40***	0.23***	0.48***	0.61***	0.48***	0.36***	−0.04	0.32***	0.10*
	(0.04)	(0.05)	(0.04)	(0.06)	(0.11)	(0.07)	(0.04)	(0.04)	(0.05)
π_{t-2}	0.11***	0.16***	−0.21***	0.02	−0.05	0.18***	0.07	−0.02	0.03
	(0.03)	(0.03)	(0.04)	(0.06)	(0.07)	(0.03)	(0.05)	(0.05)	(0.08)
π_{t-3}	0.20***	0.05	0.06	0.08*	0.27***	0.06	−0.07	0.30***	0.18***
	(0.05)	(0.04)	(0.05)	(0.04)	(0.07)	(0.09)	(0.04)	(0.04)	(0.06)
π_{t-4}	0.06**	−0.03	−0.12**	0.02	−0.15*	−0.07	−0.24***	0.02	−0.03
	(0.03)	(0.03)	(0.05)	(0.03)	(0.07)	(0.08)	(0.05)	(0.07)	(0.06)
Agriculture* π_{t-1}	0.86***	0.96**	−0.97***	−0.33	−0.4	−0.86*	0.51	0.29	0.54**
	(0.28)	(0.33)	(0.32)	(0.38)	(0.61)	(0.45)	(0.35)	(0.26)	(0.25)
Agriculture * π_{t-2}	−0.74***	−0.52**	0.72**	1.08**	0.63	0.66***	−0.21	−0.5	0.76
	(0.23)	(0.25)	(0.28)	(0.44)	(0.39)	(0.19)	(0.34)	(0.34)	(0.57)
Agriculture * π_{t-3}	0.24	−0.15	−0.33	0.09	0.37	0.23	−0.3	−0.05	−0.2
	(0.22)	(0.21)	(0.31)	(0.3)	(0.33)	(0.64)	(0.32)	(0.26)	(0.31)
Agriculture * π_{t-4}	−0.12	0.34*	1.08***	−0.55***	0.23	0.82*	0.07	−1.01*	−0.44
	(0.19)	(0.18)	(0.29)	(0.18)	(0.51)	(0.42)	(0.3)	(0.48)	(0.44)
Unemployment rate $_t$	−0.01	0.04*	0.04	−0.02*	0	0	0.06**	0.06	−0.02
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)	(0.02)
Unemployment rate $_{t-1}$	0.01	−0.01	−0.04	−0.01	−0.03	0	0.05	0.14**	−0.01
	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.05)	(0.02)
Unemployment rate $_{t-2}$	−0.01	−0.01	−0.04	0.02	−0.01	−0.01	−0.06**	−0.16***	0.01
	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.04)	(0.01)
Intercept	0.05	0.17*	0.56***	0.22***	0.60***	−0.26**	−0.17**	−0.23	0.55***
	(0.05)	(0.1)	(0.14)	(0.05)	(0.09)	(0.1)	(0.07)	(0.2)	(0.05)
n	688	688	688	688	688	688	688	688	688
R^2	0.48	0.18	0.14	0.5	0.38	0.28	0.08	0.21	0.1
LL	−403.44	−919.57	−1093.11	−580.48	−680.1	−738.19	−916.35	−1396.02	−677.71

Notes: see Table 2.
Source: Own calculations.